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Landau

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(54) **ELECTRO-CHEMICAL DEPOSITION
SYSTEM AND METHOD OF
ELECTROPLATING ON SUBSTRATES**

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205/128; 205/149; 205/153; 205/157; 204/297.01;
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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,649,509 3/1972 Morawetz et al. 204/238
3,727,620 4/1973 Orr 134/95

(List continued on next page.)

FOREIGN PATENT DOCUMENTS

58-182823 10/1983 (JP) .
63-118093 5/1988 (JP) .

04131395 5/1992 (JP) .
04280993 10/1992 (JP) .
6017291 1/1994 (JP) .
WO 97/12079 4/1997 (WO) .
WO 99/25902 5/1999 (WO) .
WO 99/25903 5/1999 (WO) .
WO 99/25904 5/1999 (WO) .
WO 99/25905 5/1999 (WO) .
WO 99/26275 5/1999 (WO) .

OTHER PUBLICATIONS

PCT Written Opinion citing additional references for PCT/
US 99/28159, dated Dec. 8, 2000.

(List continued on next page.)

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(57)

ABSTRACT

The invention provides an apparatus and a method for achieving reliable, consistent metal electroplating or electrochemical deposition onto semiconductor substrates. More particularly, the invention provides uniform and void-free deposition of metal onto metal seeded semiconductor substrates having sub-micron, high aspect ratio features. The invention provides an electrochemical deposition cell comprising a substrate holder, a cathode electrically contacting a substrate plating surface, an electrolyte container having an electrolyte inlet, an electrolyte outlet and an opening adapted to receive a substrate plating surface and an anode electrically connect to an electrolyte. Preferably, a vibrator is attached to the substrate holder to vibrate the substrate in at least one direction, and an auxiliary electrode is disposed adjacent the electrolyte outlet to provide uniform deposition across the substrate surface. Preferably, a periodic reverse current is applied during the plating period to provide a void-free metal layer within high aspect ratio features on the substrate.

29 Claims, 7 Drawing Sheets

